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INVESTIGATION OF PCBs IN DOMESTIC SUBMERSIBLE WATER WELL PUMPS

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Ontario

Ministry of the Environment

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INVESTIGATION OF PCBs

IN

DOMESTIC SUBMERSIBLE WATER WELL PUMPS

Ontario Ministry of the Environment
Water Resources Branch
Drinking Water Section
June 1987

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EXECUTIVE SUMMARY

The first part of an Ontario Environment investigation of PCBs in domestic submersible water well pumps showed that the scope of the issue is limited to relatively few wells in the province. Fewer than 1% of the 460,000 domestic water supply wells in the province have submersible pumps that could contain PCBs.

Although homeowners whose wells have pumps with PCBs are at low potential risk, Environment Ontario has developed a program to help these homeowners determine:

- if their pumps are among the relatively few that could contain PCBs; and
- if their pumps are leaking PCB oils into their water supplies.

The second part of the investigation aims at identifying wells containing PCBs that came from leaked pump motor oils, and advising affected homeowners about remedial measures.

Ministry staff will investigate cases of suspected oil leakage and possible presence of PCBs in well waters. They will sample and analyze well waters to find out if PCBs in well waters are linked to PCBs from pump motors.

While Ministry staff investigate cases where well waters are suspected of containing PCBs, the Ministry will pay for alternate water for those residents affected. The Ministry will also pay for alternate water for a maximum of 6 weeks following confirmation of PCBs in well waters.

Important findings that lead to this program for homeowners are:

- Only domestic submersible pumps with oil-cooled motors manufactured and sold in Ontario between 1964 and 1980 could contain PCBs.
- There are 2 sources of PCBs in pump motors:
  - internal capacitors; and
  - contamination of oil lubricants during processing or handling.
- Tap waters with petroleum-like taste and odours could signal pump oil leakage and possible PCB contamination.

- The scope of the potential problem in Ontario is limited because:
  - only 4,000 of the 460,000 water supply wells in the province have pumps that could contain PCBs; and
  - fewer than 100 wells per year are expected to contain detectable levels of PCBs caused by leaking pump motor oils.

One major implication of these findings relates to the potential risk to homeowners whose wells have pumps that could contain PCBs. The risk is low because:

- PCBs in submersible pump motors pose a potential risk only if pump oils with PCBs leak into water supplies.
- Leakage of PCB oils will not always result in detectable levels of PCBs in well waters. If the leakage is slow, waters could dilute PCBs in leaked oils to levels that cannot be detected in the well waters. This situation does not pose a threat.
- Waters that pick up PCBs from leaked pump motor oils are generally expected to have PCB levels within guidelines set for PCBs in drinking water. Evidence for this conclusion include:
  - PCB levels in Ontario's 2 known cases of wells with PCBs caused by leaked PCB motor oils never exceeded 0.6 ppb. (The interim objective in Ontario is 3 ppb);
  - New York and Wisconsin examined about 300 well waters suspected of containing PCBs caused by leakage of pump motor oils. Seven wells had PCB levels that exceeded 3 ppb. PCBs were not detected in 270 of these wells.

The types, makes and vintages of submersible pumps that could contain PCBs are fairly well defined. Investigators have prepared a table listing the makes of pumps that could contain PCBs, and those that do not.

This issue does not pose a widescale threat to the environment.

The investigation to date has not included municipal water supplies. There is no evidence of PCB contamination of these supplies caused by well pumps.

The first part of the investigation focused on getting technical information on the types and makes of submersible pumps with motors that

could contain PCBs, and those that do not. This work was supplemented by sampling oils from discarded pump motors and analyzing them for PCBs.

Well sampling during the first part of the investigaton was limited to just 2 wells. These 2 cases of PCBs in well waters were discovered by chance. The second part of the investigation will zero in on suspect wells for follow-up work. A large portion of the work will involve sampling suspect wells and analyzing the samples.

The investigation began following the discovery that PCB oils had leaked from a submersible pump and contaminated a well in Stouffville.

1.0 INTRODUCTION

This report presents the work and findings for the first part of Environment Ontario's investigation of PCBs in domestic submersible water well pumps. It also outlines an action plan for work during the second part. This plan was designed to help residents determine if their pumps and wells are among the relatively few in the province that could contain PCBs.

The first part of the investigation aimed at finding out the nature and scope of the potential problem of PCBs in domestic water well pumps in the province. To do this, investigators focused on:

- getting technical information on submersible pumps used in domestic water supply wells;
- identifying the makes and vintages of pumps that could contain PCBs; and
- assessing the numbers of suspect pumps in the province.

Technical information detailed the type of submersible pumps that could contain PCBs, and those that do not contain PCBs. It also explained sources of PCBs in pump motors and how PCBs move from pump motors to well waters.

Surveys of the submersible pump industry provided information on the scope of the potential problem. It resulted in an estimate of the number of suspect pumps still in service, and in a table listing makes of pumps that could contain PCBs and those that do not.

Data on PCB levels in submersible pump motors and in well waters allowed investigators to assess the potential risk to homeowners whose pumps contain PCBs. New York and Wisconsin provided most data on well waters with PCBs that came from submersible pumps. In Ontario, there were only 2 known cases of well waters with PCBs from pumps.

Sampling for PCBs in wells in Ontario was limited to the 2 cases mentioned above. These cases were discovered by chance. The second part of the investigation will emphasize sampling suspect wells.

The investigation to date has not included municipal water supplies or pumps used with these supplies. There is no evidence of PCBs in municipal water supplies caused by well pumps.

The second part of the investigation aims at identifying wells with PCBs that came from leaked pump motor oils, and advising affected homeowners about remedial measures. The province's action plan will help investigators zero in on suspect wells for follow-up work. A large portion of this work will involve sampling suspect wells and analyzing the samples.

2.0 BACKGROUND INFORMATION

This investigation followed the discovery that a submersible pump had contaminated a domestic well in Stouffville with PCBs. Evidence showed that PCB-contaminated oil had leaked from the well's pump motor into the water supply. The oil contained 95 parts per million (ppm) Aroclor 1254 (a PCB isomer), and the water contained up to .0006 ppm (0.6 parts per billion (ppb)) of the same Aroclor. The pump was manufactured by Sta-Rite Inc. in 1966.

The initial purpose of the investigation was to find out if other Sta-Rite pumps contained PCBs. Investigators sampled oils from 3 discarded Sta-Rite pump motors. The presence of PCBs in 2 of these oils (20 ppm and 13 ppm) suggested that other Sta-Rite pump motors could contain oils with PCBs.

Subsequent reports from New York and Wisconsin confirmed that submersible pumps of other manufacturers also had motors containing oils with PCBs.

At this point, the province broadened the scope of its investigation to include pump motors of other manufacturers. Investigators analyzed oils collected from motors manufactured by

Century, F.E. Myers, Red Jacket, and REDA, and from additional Sta-Rite pumps.

The investigation of discarded pumps revealed the levels of PCBs in pump motor oils, but supplied limited information on the types and makes of pumps in service that could contain PCBs.

To obtain this information, and also find out the nature and potential scope of this issue in the province, investigators focused on getting:

- technical information on domestic submersible pumps; and
- information on the market for these pumps in the province.

3.0 OBJECTIVES OF THE INVESTIGATION

There were 4 objectives. These were:

(i) to find out the range of PCB concentrations in pump motor oils;
(ii) to find out the range of PCB concentrations in well waters with PCBs that came from pump motor oils;
(iii) to specify the types and makes of pumps that could contain PCBs and those that do not; and
(iv) to estimate the scope of the potential problem in the province, and the potential risk to residents whose pumps contain PCBs.

4.0 TECHNICAL INFORMATION ON PUMPS USED IN DOMESTIC WATER SUPPLY WELLS

Investigators reviewed technical information on water well pumps to help them identify the types of pumps that could contain PCBs.

A summary of the reviewed technical information follows. Versar Inc. (1979) and Humes et al. (1986) provide detailed information on submersible pumps and their motors.

4.1 Types of Pumps Used in Domestic Water Supply Wells

Two types of pumps commonly used to withdraw water from domestic wells are:

- Jet pumps
- Submersible pumps

Both types of pumps have a pump unit and a motor unit.

They differ in the following ways:

Jet Pumps	Submersible Pumps
• No moving parts in well bore; motor unit and pump unit located above ground.	• Motor unit and pump unit submerged in the well.
• Can pump from a maximum depth of 150 to 200 feet.	• Can pump from any well depth.

The rest of this section on technical information deals with submersible pumps only. Jet pumps and other pumps with the pump motor unit located above ground are not linked to PCB contamination of well waters.

4.2 Description of Submersible Water Well Pumps

Submersible pumps consist of 2 units - an upper pump unit coupled to a lower motor unit (Figure 1). Both units are submerged in well water.

CUTAWAY VIEW OF A DOMESTIC SUBMERSIBLE PUMP

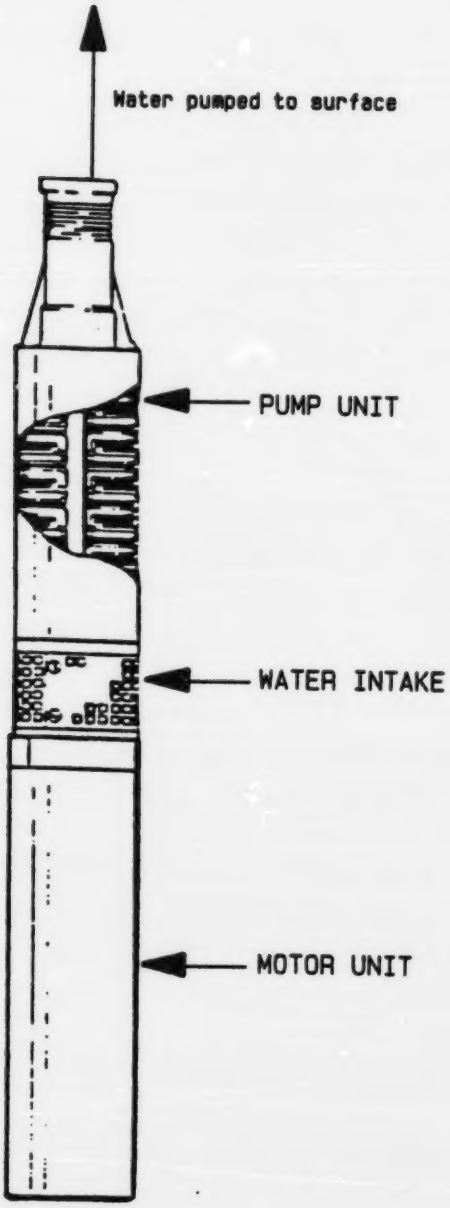

FIGURE 1. A submersible pump which has an upper pump unit coupled to a lower motor unit.

Submersible pumps used in domestic water supply wells have motors that are:

- 3-inch or 4-inch in diameter
- single phase
- fractional horsepower
- oil-filled or water-filled

4.3 Power Supply Configurations of Single Phase Motors Used in Domestic Submersible Pumps

Single phase motors of domestic submersible pumps have 2 windings - a primary winding and a secondary winding. These windings generate magnetic fields that cause the rotor and impellers in the pump unit to rotate.

These motors control the timing of the magnetic field in each winding. They do this by ensuring that the electric current in the primary and secondary windings are out of phase.

Capacitors and other devices attached to these motors provide the required out-of-phase current by producing a leading current in the secondary winding. A device which provides a similar effect consists of a secondary winding with additional built-in reactance. Permanent split-phase motors contain this device.

Power supply configurations to these motors depend on the location of the capacitor or other device in relation to the pump motor. Figure 2 shows common power supply configurations. These are discussed below.

4.3.1 Two-wire power supply with internal capacitor

This is the configuration used in most two-wire single phase electric motors.

The single lead wire provides power to the primary and secondary windings. The secondary winding has a permanent capacitor in its circuit.

THE NUMBER OF PUMP WIRES INDICATES CAPACITOR LOCATION IN SINGLE PHASE MOTORS OF DOMESTIC SUBMERSIBLE PUMPS

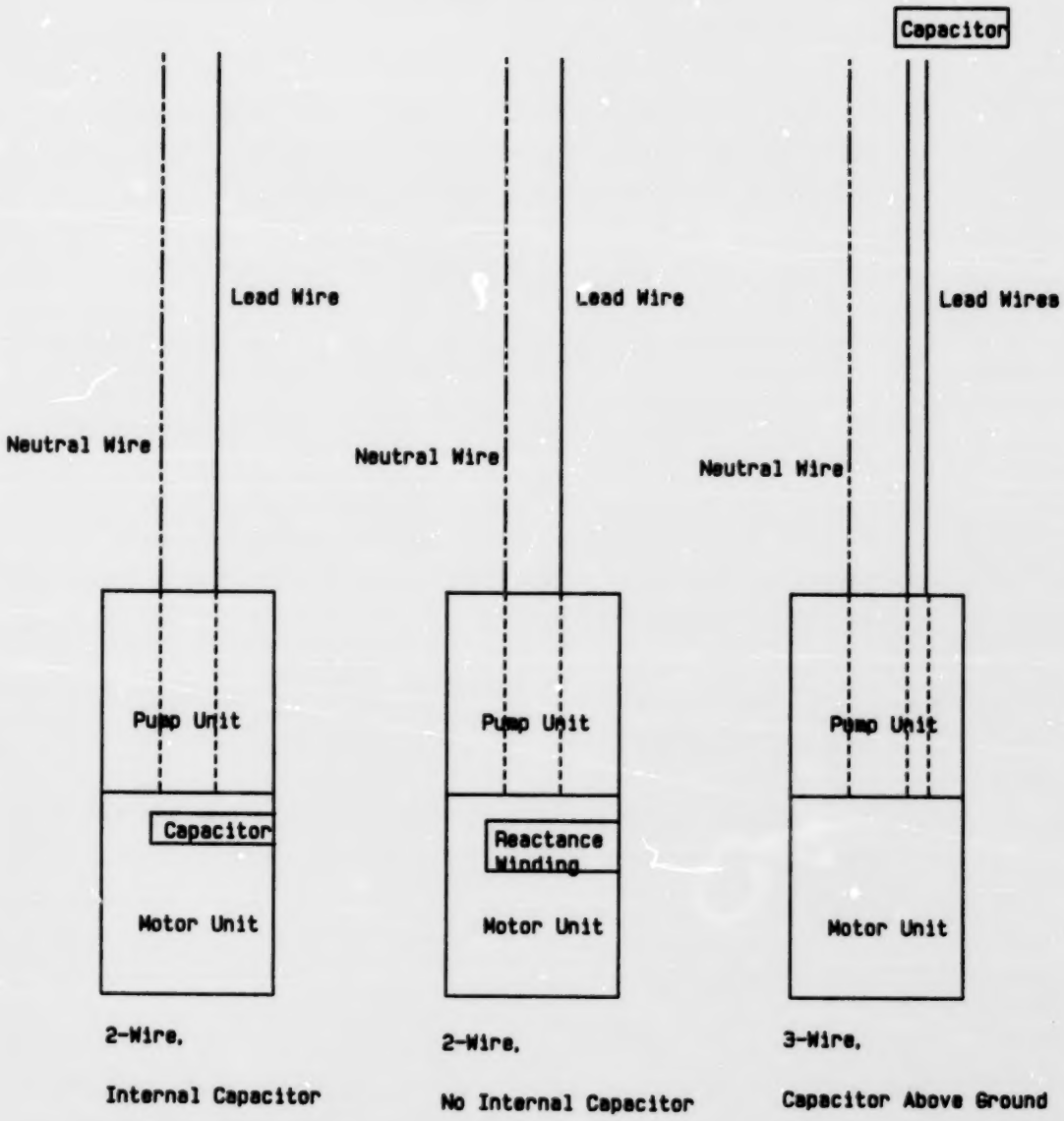

FIGURE 2. Common power supply configurations in single phase motors used in domestic submersible water well pumps. The number of wires does not include the ground wire.

The capacitor was usually built into the motor. It was sometimes put in a small housing attached to the base of the motor casing.

4.3.2 Two-wire power supply with no internal capacitor

This configuration was not commonly used in domestic submersible pumps.

The single lead wire provides power to the primary and secondary windings. The secondary winding has a built-in reactance, and there is no internal capacitor.

Permanent split-phase motors used this configuration.

4.3.3 Three-wire power supply with capacitor above ground

This configuration was used in the majority of submersible pumps sold in Ontario.

A capacitor is installed in a control box above ground. Separate lead wires leave the control box for the primary and secondary motor windings.

4.4 Oil-Filled and Water-Filled Motors Used in Domestic Submersible Pumps

There are 2 design variations that protect submerged two-wire and three-wire pump motors from exposure to well water. These are:

(i) Oil-filled motors

A protective metal housing encloses the motor and its oil reservoir (Figure 3). This housing has a seal at the upper shaft end and a diaphragm or solid cap at the bottom end. The seal, diaphragm and solid cap retard leakage of motor oils into water supplies.

These oils are in contact with motor windings and internal capacitors.

CUTAWAY VIEWS OF OIL-FILLED AND WATER-FILLED PUMP MOTORS

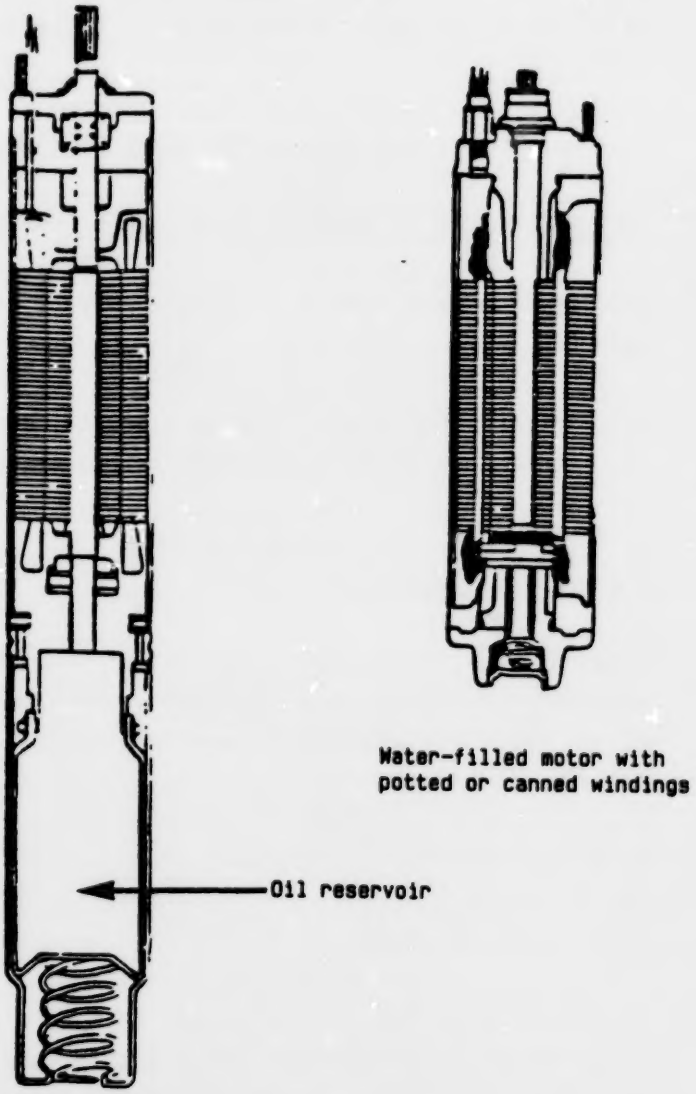

Figure 3. Views of oil-filled motors with open windings and water-filled motors with potted or canned windings.

They are food-grade mineral oils.

(ii) Water-filled motors

Windings in this type of motor are sealed in an epoxy-filled stainless steel can, and the motor is filled with water (Figure 3).

This water does not contact the motor windings.

5.0 SOURCES OF PCBs IN DOMESTIC SUBMERSIBLE PUMP MOTOR OILS

Results from work done in Ontario, New York and Wisconsin suggest 2 main PCB sources. These are:

- internal capacitors, the main source; and
- contamination while handling or processing the pump motor oils.

5.1 Internal Capacitors

Internal capacitors used in domestic submersible pump motors manufactured between 1964 and 1980 could have contained oils with PCBs. These PCB oils could leak from capacitors and contaminate oils in oil-filled motors.

Capacitors manufactured between 1964 and 1978 contained approximately 5 ounces of a dielectric fluid. In some cases, this fluid contained PCBs.

Capacitors with PCB oils were used in motors of some submersible pumps manufactured between 1964 and 1978, and perhaps to 1980. Canadian regulations allowed pump motor manufacturers to use capacitors manufactured or imported up to July 1, 1980. Versar Inc. (1979) reported that U.S. manufacturers switched to PCB-free capacitors in late 1977.

5.2 Contamination While Handling or Processing the Pump Motor Oils

Pump manufacturers in Canada and the U.S. claim they always used PCB-free mineral oils in their pump motors.

Despite this claim, evidence suggests PCB contamination could have occurred during handling or processing of the oils. Investigators found PCBs in some oil-filled motors that did not have internal capacitors with PCBs.

The absence of PCBs in some oil-filled motors without internal capacitors indicates that motor oils were not always contaminated, and could be free of PCBs.

6.0 TYPES OF SUBMERSIBLE PUMPS THAT COULD CONTAIN PCBs, AND THOSE THAT DO NOT

Descriptions of these 2 types of submersible pumps reflect the type of motor in the pump.

Submersible pumps with these types of motors could contain PCBs	Submersible pumps with this type of motor do not contain PCBs
• Motor is oil-filled (with or without internal capacitor), and was manufactured between 1964 and 1980.	• Motor is water-filled, and does not have an internal capacitor.
• Motor is water-filled, has an internal capacitor, and was manufactured during the same period.	

These summary descriptions follow from previous discussions on types of submersible pump motors and sources of PCBs in these motors.

7.0 MECHANISM BY WHICH PCBs IN SUBMERSIBLE PUMP MOTOR OILS GET INTO WATER SUPPLIES

PCBs can get into water supplies only if oils with PCBs leak from submersible pump motors. Leakage usually occurs at worn-out seals.

Pump oils can pick up PCBs from leaking PCB capacitor oils, and leak them to water supplies.

8.0 TYPES OF SUBMERSIBLE PUMPS THAT COULD LEAK PCBs INTO WELL WATER SUPPLIES, AND THOSE THAT DO NOT

Only submersible pumps with oil-filled motors manufactured between 1964 and 1980 could leak PCBs into well waters. PCB oils could be present in this type of motor, and could leak into well waters.

Submersible pumps with water-filled motors do not leak PCBs into well waters. The most popular brand of water-filled motors is made by Franklin Electric, and does not contain PCBs. Other water-filled motors could have internal capacitors with PCBs. However, these PCBs could not get into water supplies. The capacitor and its associated windings are sealed in a stainless steel container, and they do not contact well waters.

9.0 WELL WATER INDICATORS THAT COULD SIGNAL PUMP OIL LEAKAGE AND THE POSSIBLE PRESENCE OF PCBs IN A WATER SUPPLY

Well water indicators that commonly signal pump oil leakage are:

- water has petroleum-like taste and odour; and
- there is an oil-like film on water and fixtures.

They are caused mainly by leaked motor oils, and not by PCBs that could be present in the oils.

The presence of these indicators does not necessarily indicate oil leakage. Common water problems such as iron could also produce these indicators.

These indicators could signal the presence of PCBs in a water supply only if the leaked oil contained PCBs.

If a leaked motor oil does not contain PCBs, these indicators could still be present, but the affected water supply would not contain PCBs.

Leakage of motor oils does not always produce well water indicators. Slow leaks can go undetected because water dilutes the leaked oils.

10.0 WORK CONDUCTED

Investigators sampled oils from discarded pump motors to determine the range of PCB concentrations in these oils. They collected 40 oil samples from pumps of 5 manufacturers. The motor manufacturers were Century, F.E. Myers, Red Jacket, REDA, and Sta-Rite. All pumps were manufactured before 1980.

Repeated sampling of waters from 2 wells provided data on the range of PCB concentrations in contaminated well waters. These are the only wells in the province known to have this type of contamination.

Surveys of pump manufacturers, distributors and installers in Canada and the U.S. provided information on the types and makes of pump motors that could contain PCBs, and those that do not contain PCBs.

Investigators asked pump manufacturers about the pumps they manufactured between 1964 and 1980, and after 1980. Manufacturers provided information on:

- the name(s) of pump motors they used;
- the presence and location of capacitors; and
- the type of coolant/insulant in their motors.

Results from the surveys of the pump industry together with data in published reports helped investigators estimate the scope of the potential problem in the province.

11.0 RESULTS OF THE INVESTIGATION

11.1 The Pump Motor Market in Ontario and Its Implications on the Scope of the Potential Problem

Results from surveys of pump manufacturers, distributors and installers in Ontario show that a large majority of pumps sold in the province have Franklin Electric motors. These motors are water-cooled and do not contain PCBs. These findings suggest that the scope of the potential problem is limited.

Franklin Electric has dominated the domestic pump motor market in the province (Figure 4). This manufacturer claims a 75-80% share of the market during the past 15 years. Two of its competitors support this claim. Additional support comes from the large number of pump manufacturers that use these motors in their pumps (see Table 1 on page 19). Franklin Electric does not make pumps.

Several competitors shared the remaining 20-25% of the pump motor market. The major ones included Century Electric, F.E. Myers, Red Jacket, REDA and Sta-Rite. Peabody Barnes and others accounted for only a small portion of this market share.

The scope of the potential problem of PCBs in well pumps in the province is limited. This conclusion follows an analysis of the types of motors made by Franklin Electric and its competitors, and of their respective market shares. Franklin Electric motors have always been water-filled and PCB free. Motors manufactured by its major competitors between 1964 and 1980 were oil-filled and could have contained internal capacitors. These motors are suspected of containing PCBs. The majority of pumps sold in Ontario between 1964 and 1980 had Franklin Electric motors. The remaining pumps sold during this period used motors of Franklin Electric's competitors, and could have contained PCBs. The majority of these suspect pumps have already been replaced through attrition.

FRANKLIN ELECTRIC MOTORS HAVE DOMINATED THE SUBMERSIBLE PUMP MOTOR MARKET IN ONTARIO

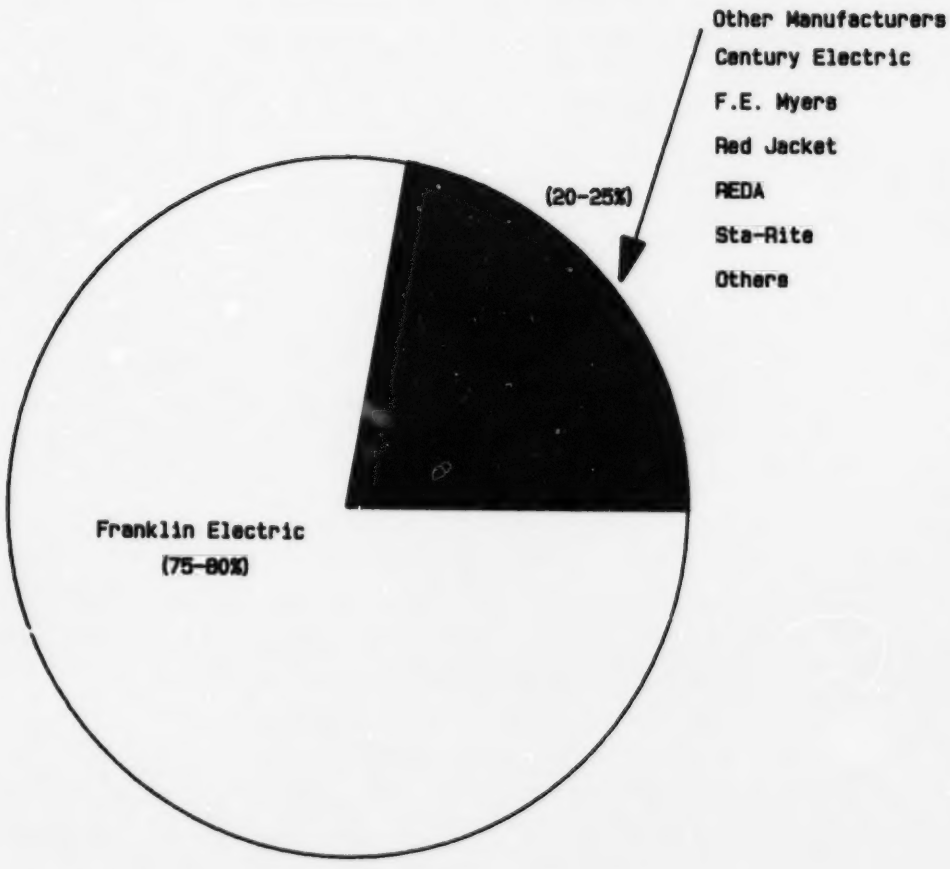

FIGURE 4. The market share distribution for manufacturers of motors used in domestic submersible pumps, and sold in Ontario between 1964 and 1980.

11.2 PCB Concentrations in Submersible Pump Motor Oils

Oils from 25 of the 40 discarded pump motors showed PCB levels of up to 1% (Figure 5). The remaining 15 did not contain PCBs. PCBs were identified as Aroclor 1242, 1254 and 1260 (PCB isomers). The pumps with PCBs were manufactured before 1980 by F.E. Myers, REDA and Sta-Rite Inc. The 15 pumps without PCBs were manufactured by Century, F.E. Myers, REDA, Red Jacket and Sta-Rite before 1980.

New York and Wisconsin reported levels of up to 33% in 67 of the 107 pump oils sampled.

The level of PCBs in motor oils appears to reflect the PCB source.

- Low levels of up to a few hundred parts per million suggest:
  - PCB contamination during handling or processing of oils; and/or
  - a minor leak of PCB oils from an internal capacitor.
- Higher levels in the range of up to thousands of parts per million suggest significant leakage of PCB oil from an internal capacitor. (Alberta reported 66% PCBs in a capacitor from a 1975 REDA motor. The oil contained 720 ppm PCBs).

Ontario investigators analyzed samples of 2 oils used in motors manufactured after 1984. Neither sample contained PCBs. One of the oils is used in Sta-Rite motors. The other, Esso-Voltesso 35 (SO515) is used in motors of other manufacturers.

Appendix A has details on the pumps sampled in Ontario. Information includes the pump/motor name, pump serial number, pump model number, year manufactured, operating voltage, horsepower, and other identification marks, and analytical data.

Results for 3 of 4 sets of replicates analyzed at separate laboratories were comparable. PCB levels in the fourth set were reported as 95 ppm, 74.5 ppm and <1.0 ppm. There is no explanation for this discrepancy.

PCBs FOUND IN OILS FROM 25 OF 40 DISCARDED PUMP MOTORS

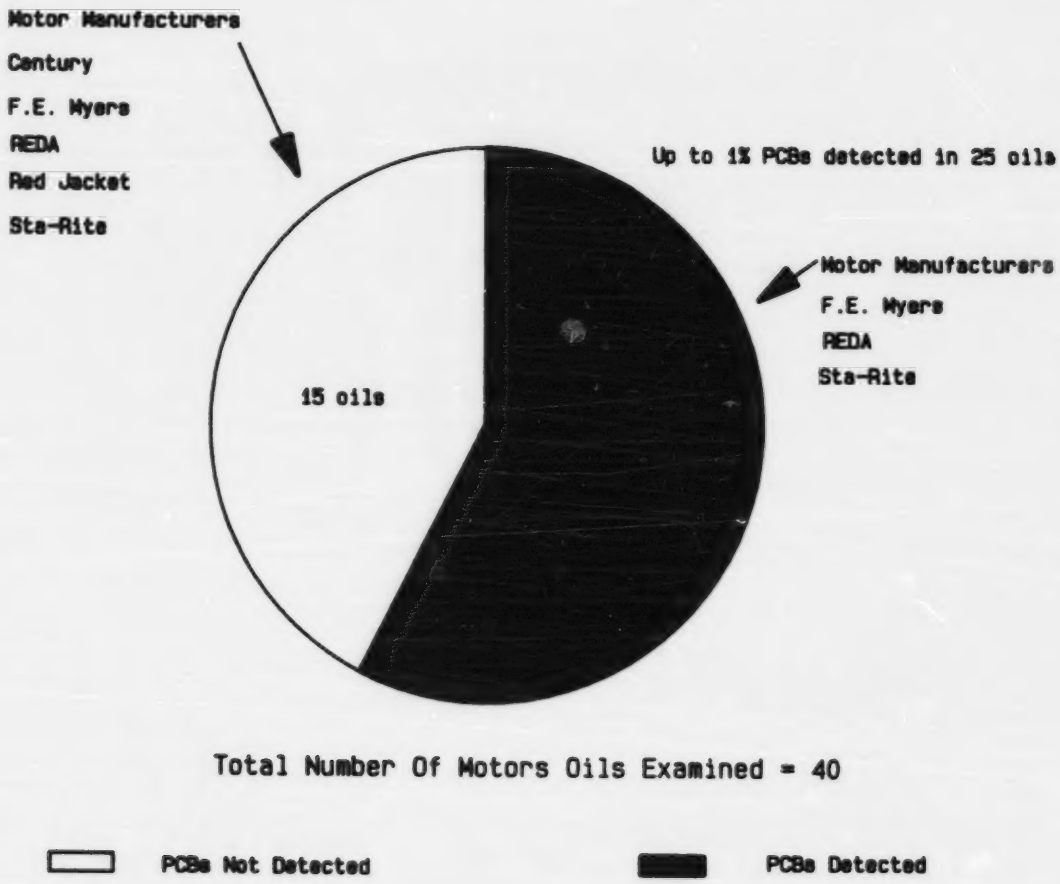

Figure 5. Presence/absence of PCBs in motor oils collected from discarded pumps. Detection limit for PCBs in these oils = 5ppm. (10,000 ppm = 1%)

Appendix B contains results for the replicate analyses. The laboratories included Ontario Ministry of the Environment, Environmental Testing and Certification in New Jersey, CBC-AquaSearch in Wisconsin, and the University of Wisconsin.

Sta-Rite Inc. provided data showing the absence of PCBs in some of their pump motors manufactured before 1980. Sta-Rite Inc. collected oil samples from discarded Sta-Rite pump motors, and CBC-AquaSearch in Wisconsin analyzed the samples. Appendix C provides these results.

11.3 PCB Concentrations in Well Waters

PCB levels never exceeded 0.6 ppb in the 2 Ontario wells with PCBs caused by leakage of pump motor oils containing PCBs. The value of 0.6 ppb is far below Ontario's interim objective of 3 ppb PCBs in drinking water.

New York investigated about 200 wells suspected of containing PCBs caused by submersible pumps. Thirteen of the wells had PCBs. Only three of these had PCB levels greater than 3 ppb.

Wisconsin reported finding PCBs in 17 of 90 wells suspected of containing PCBs from submersible pumps. Only 4 of the 17 wells had PCB levels greater than the 3 ppb.

11.4 Makes of Submersible Pumps That Could Contain PCBs, and Those That Do Not

Table 1 has separate lists of domestic submersible water well pumps with motors that satisfy criteria for pumps that could contain PCBs and those that do not. These makes of pumps were manufactured between 1964 and 1980. The pumps mentioned in this table were commonly sold in Ontario during the reference period.

TABLE 1: **Names of domestic submersible water well pumps with motors manufactured between 1964 and 1980 that could contain PCBs and those that do not contain PCBs. Only the names of pumps commonly sold in Ontario during this period are mentioned.**

MOTORS COULD CONTAIN PCBs (oil-filled, with or without internal capacitors)			MOTORS DO NOT CONTAIN PCBs (water-filled, no internal capacitor)
Name of Pump Manufacturer (Pump Name)	Name of Motor Manufacturer (Motor name)	Reasons Why Motor Could Contain PCBs	Manufacturers of the following pumps used Franklin Electric motors:
Aeromotor[2]	Century Electric	O	Aeromotor[2]
Berkeley[2]	Century Electric	O	Beatty
F.E. Myers (before 77/78)	F.E. Myers	O, C	Berkeley[2]
Peabody Barnes	Peabody Barnes	O, C	Goulds
Pumptron	Century Electric	O	Grundfos
Red Jacket[2]	Century Electric	O	GSW
Red Jacket[2]	Red Jacket	O, C	Home Hardware
REDA	REDA	O, C	Jacuzzi
Sears (75-78)[1],[2]	Sta-Rite	O	Layne & Bowler
Sta-Rite (U.S.)	Sta-Rite	O, C O	McDougall
Standard	REDA	O, C	Monarch
Tait	Century Electric	O	Pioneer
Webtrol[2]	Century Electric	O	Pumps & Softeners
			Sears[2]
			Sta-Rite (GSW)
			Southern
			Webtrol[2]
			F.E. Myers pumps with F.E. Myers motors (after 77/78)

O = oil-filled
C = Capacitor in motor.

[1]Manufactured during this time only.
[2]Used motor of more than 1 manufacturer.

Source: Environment Ontario survey of the pump industry.

Environment Ontario results confirmed PCBs in pumps manufactured by F.E. Myers, REDA and Sta-Rite. Similar work in New York and Wisconsin supported Ontario's results.

11.5 Scope of the Potential Problem of Pumps with PCBs in Ontario

Results from surveys of pump manufacturers, distributors and installers in Ontario and the U.S. suggest an overwhelming majority of domestic water wells in the province are free of potential PCB contamination by submersible pumps. The majority of suspect pumps manufactured between 1964 and 1980 have already been replaced. The current scope of the problem is limited to the relatively few of these pumps still in service that could contain PCBs.

Wells containing pumps that could contain PCBs represent fewer than 1% (4,000) of the 460,000 domestic water supply wells in the province. Figure 6 shows the current scope of the potential problem of PCBs in water supply wells that have submersible pumps manufactured between 1964 and 1980.

The scope of the potential problem will decrease with time because homeowners will gradually replace 1964-1980 pumps when they fail. Suspect pumps that could contain PCBs will be among those replaced.

Only 35% of submersible pumps sold in Ontario between 1964 and 1980 are still in service. Approximately 61,000 were sold during this period, but only 21,600 were still in service in 1986. Figure 7 shows yearly sales figures for submersible pumps and for those still in service. Sales for 1964 to 1976 were estimated. The number of 1964-1980 submersible pumps in service was derived from data on sales figures and the life cycle of submersible pump motors (Figure 8). This graph shows how the percentage of pumps in service decreases with pump age. Submersible pump motors have an average life expectancy of about 8 years.

FEWER THAN 1% OF DOMESTIC WATER SUPPLY WELLS IN ONTARIO HAVE 1964-1980 SUBMERSIBLE PUMPS THAT COULD CONTAIN PCBs

FEWER THAN 100 WELLS PER YEAR ARE EXPECTED TO CONTAIN DETECTABLE LEVELS OF PCBs CAUSED BY THESE PUMPS

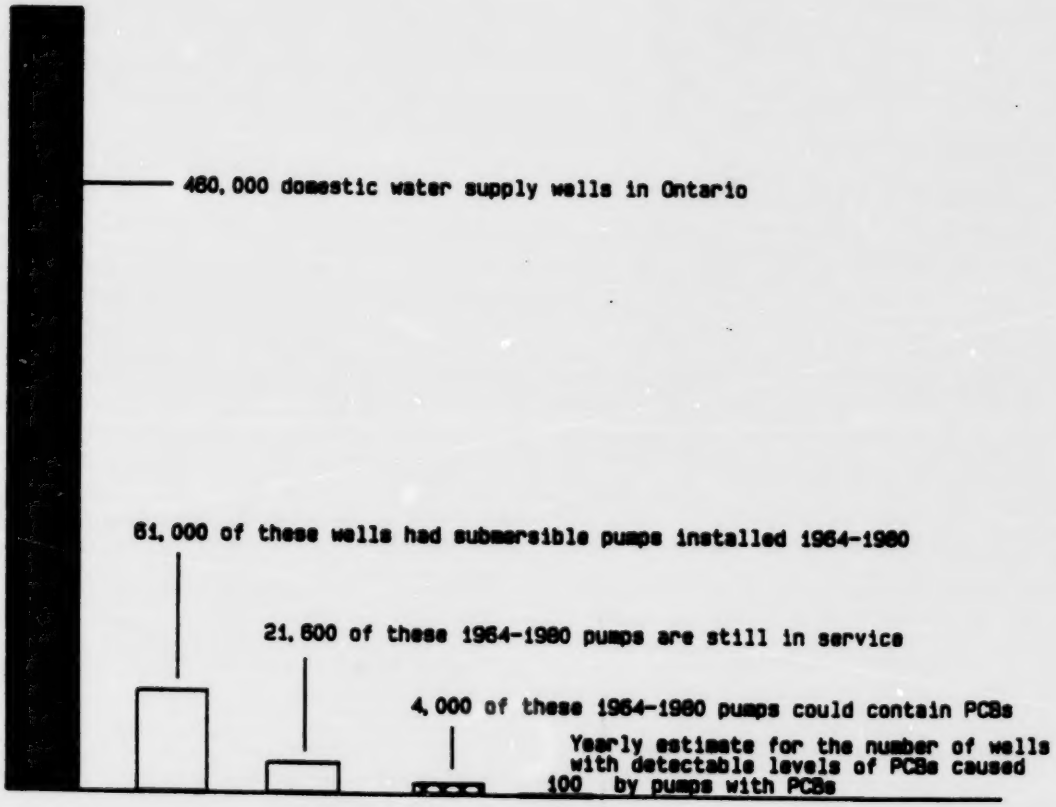
460,000 domestic water supply wells in Ontario
61,000 of these wells had submersible pumps installed 1964-1980
21,600 of these 1964-1980 pumps are still in service
4,000 of these 1964-1980 pumps could contain PCBs
Yearly estimate for the number of wells with detectable levels of PCBs caused by pumps with PCBs
100

FIGURE 6. The current scope of the potential problem of PCBs in domestic water supply wells that have submersible pumps manufactured between 1964 and 1980.

35% OF SUBMERSIBLE PUMPS SOLD IN ONTARIO BETWEEN 1964-1980 ARE STILL IN SERVICE

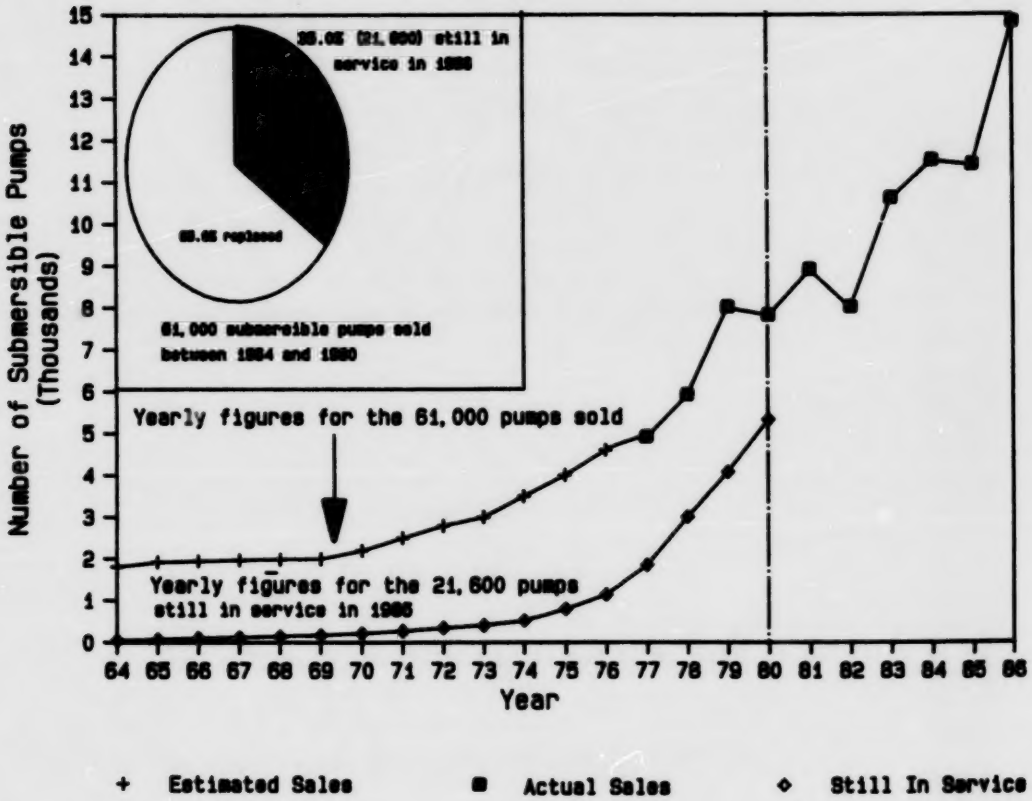
35.0% (21,000) still in service in 1986
65.0% replaced
61,000 submersible pumps sold between 1964 and 1980
Yearly figures for the 61,000 pumps sold
Yearly figures for the 21,600 pumps still in service in 1986
Number of Submersible Pumps (Thousands)
Year
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
+ Estimated Sales
■ Actual Sales
◇ Still In Service

FIGURE 7. Yearly figures for domestic submersible pumps sold in Ontario between 1964 and 1980, and for those pumps still in service in 1986.

CHANGES IN THE PERCENTAGE OF PUMPS IN SERVICE WITH PUMP AGE

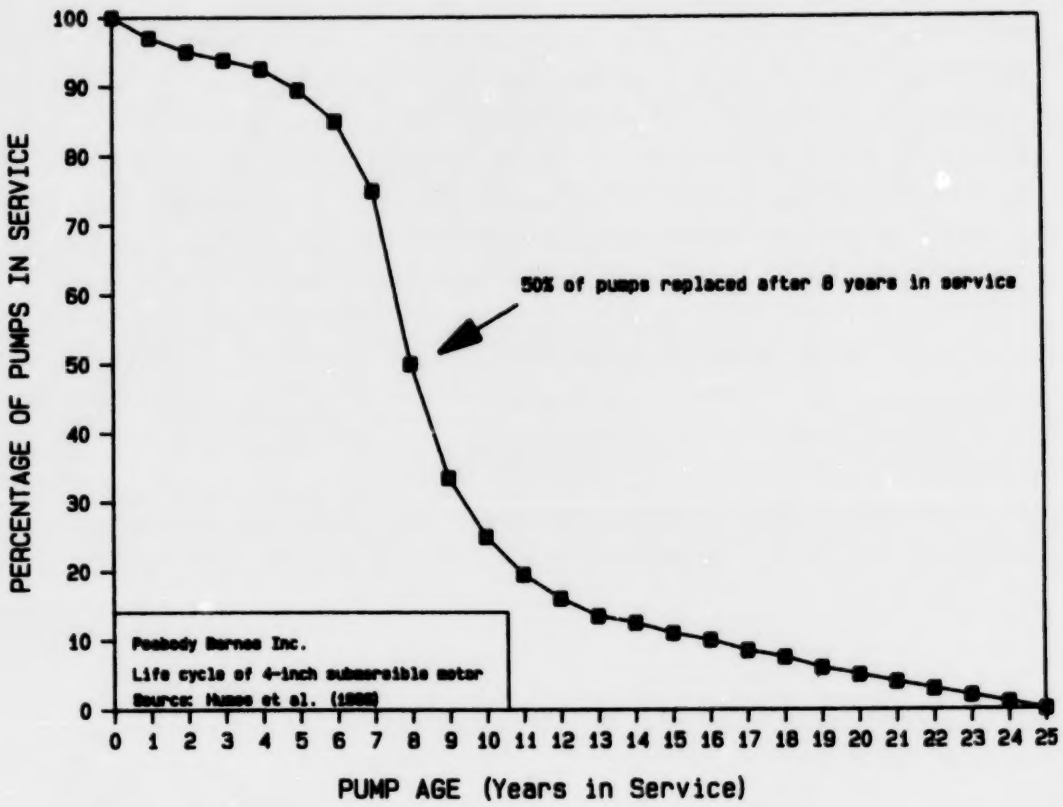

FIGURE 8. The life cycle of submersible pump motors. Submersible pump motors have an average life expectancy of about 8 years.

Approximately 4,000 submersible pumps manufactured between 1964 and 1980 and still in service in 1986 could contain PCBs. Figure 9 shows yearly estimates for 1964-1980 pumps in service, and for those that could contain PCBs. Estimates for the number of pumps that could contain PCBs resulted from an analysis of the pump motor market in Ontario. About 20% of pumps sold annually during the period are suspect. The remaining 75%-80% had Franklin Electric motors. These motors are PCB-free because they are water-cooled, and do not contain internal capacitors with PCBs.

Fewer than 100 wells per year are expected to contain detectable levels of PCBs caused by leaking pump oils. Results from investigations in New York and Wisconsin during the past year support this estimate. Investigators in these states reported PCBs in about 60 wells suspected to contain PCBs that leaked from pump motors. Wisconsin estimates that tens of thousands of wells in the state have pumps with PCBs. Despite this large number, they confirmed PCBs in fewer than 50 wells during the past year. A similar trend for Ontario suggests a yearly estimate of fewer than 100 cases of well waters with detectable levels of PCBs caused by submersible pumps.

A larger number of 1964-1980 pumps could leak oils into water supplies each year. However, leakage does not result in detection of PCBs if:

- the oil is free of PCBs; or
- the leakage of PCB oil is slow. Slow leaks are not always detected because water dilutes the leaked oils.

Investigators made 3 assumptions in order to get reasonable estimates for pumps still in use, and pumps that could contain PCBs. These assumptions are:

- all pumps unaccounted for could contain PCBs;
- the relative market share for the major manufacturers during the past 15 years reflects the market between 1964 and 1980; and
- submersible pump motors of all manufacturers deteriorate at the same rate.

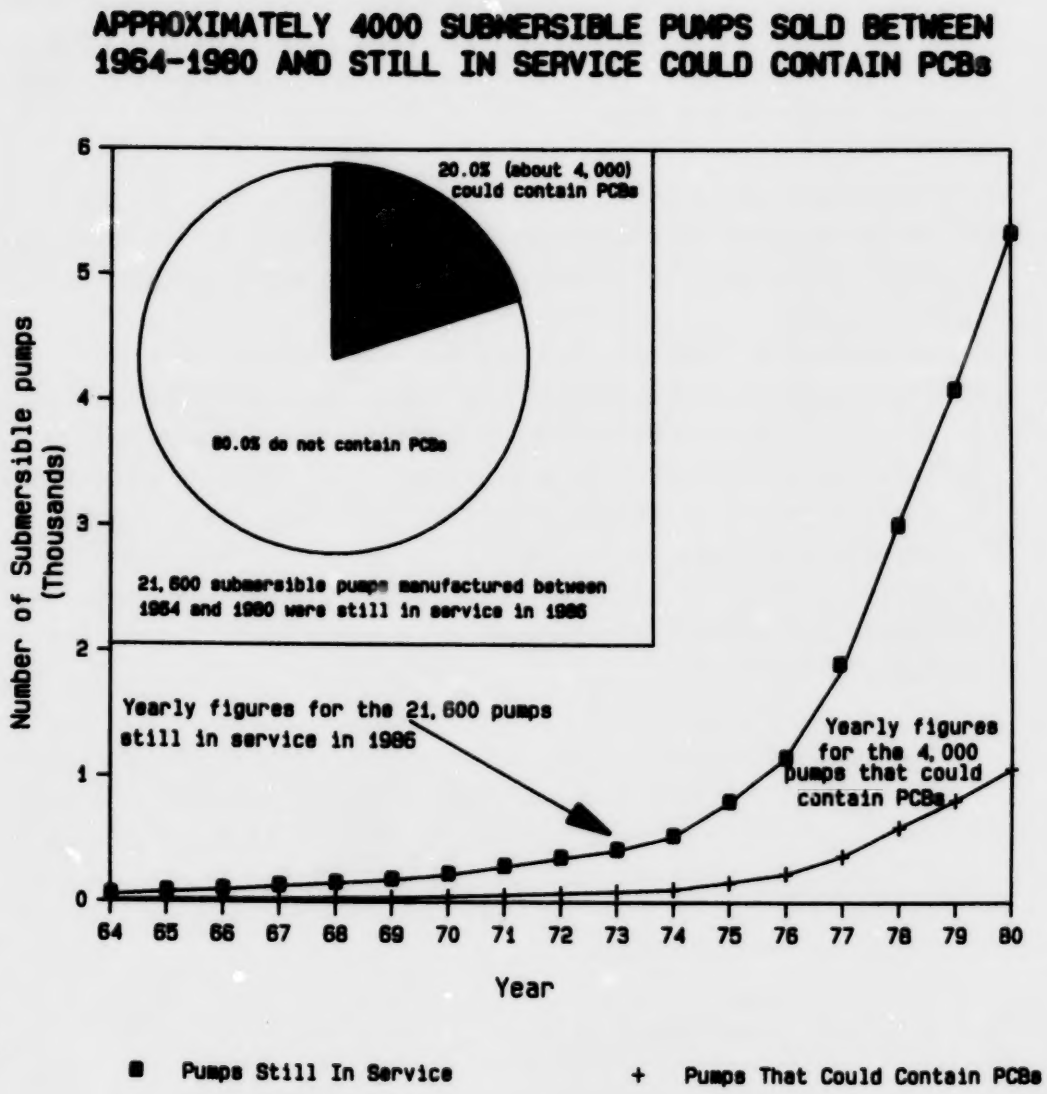
APPROXIMATELY 4000 SUBMERSIBLE PUMPS SOLD BETWEEN 1964-1980 AND STILL IN SERVICE COULD CONTAIN PCBs
20.0% (about 4,000) could contain PCBs
80.0% do not contain PCBs
21,600 submersible pumps manufactured between 1964 and 1980 were still in service in 1986
Number of Submersible pumps (Thousands)
Yearly figures for the 21,600 pumps still in service in 1986
Yearly figures for the 4,000 pumps that could contain PCBs
Year
Pumps Still In Service
Pumps That Could Contain PCBs

FIGURE 9. Yearly figures for domestic submersible pumps sold in Ontario between 1964 and 1980 and still in service in 1986, and for those pumps that could contain PCBs.

There are no accurate records for pumps sold in Ontario between 1964 and 1976.

12.0 POTENTIAL RISK POSED BY PCBs IN SUBMERSIBLE PUMPS

The majority of residents on private water supply wells are at no risk because more than 99% of these wells have submersible pumps without PCBs. Fewer than 1% of these wells have submersible pumps that could contain PCBs.

The presence of PCBs in submersible pump motors does not pose a health risk to individual homeowners. A potential risk is present only if pump motor oils with PCBs leak into water supplies.

Water quality data from contaminated wells suggest that even those individuals who have leaking submersible pumps with PCBs are at low risk. Levels of PCBs present in water supplies were generally well below guidelines for PCBs in drinking water. PCBs in the 2 wells investigated in Ontario never exceeded the province's interim objective of 3 ppb. New York and Wisconsin examined about 300 wells suspected of containing PCBs. Only 7 wells contained PCBs at levels above 3 ppb. Two hundred and seventy wells did not contain PCBs.

Leakage of PCB motor oils will not have a widescale impact on the environment. Leaked oils would not generally move from within well casings into ground-water aquifers. Instead, they are diluted and pumped to the surface, or float on water trapped in well casings. In the latter case, flushing affected wells and casings with detergent removes these oils.

13.0 PLANS FOR FUTURE WORK

Future work aims to do 3 things. These are:

(i) issue a press release to notify the public of our work and findings;
(ii) identify wells contaminated by PCBs from submersible pumps; and
(iii) advise homeowners with contaminated wells about remedial measures.

13.1 Protocol

This protocol was developed to handle initial enquiries that will follow a press release. It may have to remain in effect for several years until all suspect pumps have been replaced.

The following steps outline how Ministry staff will handle homeowners' enquiries and provide follow-up work.

Step:

1. The Ministry prepares a press release, and newspapers alert the public to our work and findings based on the press release.

2. Homeowners who suspect contamination of their pumps and wells will contact local offices of our Ministry.

   Staff will mail an information kit (Appendix D) to homeowners who request same. This kit shows homeowners how to identify the type and make of pump in the well.

   Homeowners will return completed questionnaires to the Ministry.

3. The Ministry will sample well water and analyze for PCBs if suspect wells satisfy all of the following criteria:

   (a) well waters have indicators (petroleum-like taste and odour) of possible oil leakage;
   (b) investigators have ruled out common causes of these indicators, and implicate leakage of motor oils as a possible cause;
   (c) homeowners provide all required information on the pump;
   (d) the well pump is submersible, oil-filled, and was manufactured between 1964-1980; and
   (e) the make of pump is on the Ministry's list of pumps implicated. If the pump/pump motor combination is not on this list, the Ministry will do follow-up work to find out if it could contain PCBs.

4. While Ministry staff investigate cases where well waters are suspected of containing PCBs (i.e. the wells have satisfied all criteria noted in step 3), the Ministry will pay for alternate water for those residents affected.

5. If Ministry staff confirm that submersible pumps have contaminated well waters with PCBs, they will advise homeowners about remedial measures. These will include replacing pumps, and flushing well casings with detergent to remove residual oil in the wells. The Ministry will pay for alternate water for a maximum of 6 weeks following confirmation of PCBs in well waters.

6. The Ministry will ensure that the disposal of pumps with PCBs is done properly.

14.0 SUMMARY AND CONCLUSIONS

PCBs in submersible water well pumps do not pose a major problem for the environment. The estimated 4,000 submersible pumps that are still in use and could contain PCBs are not expected to cause widespread contamination of ground-water resources.

The overwhelming majority of residents on private domestic water supplies in the province do not have this potential problem of PCBs in their water supplies. Fewer than 1% of the 460,000 private wells have pumps suspected of containing PCBs.

The issue poses a minor risk to residents who have pumps with PCBs. Data from Ontario, New York and Wisconsin show that PCB levels in the majority of cases of well waters with PCBs were below Ontario's interim objective of 3 ppb.

The scope of the problem in the province is fairly well defined because the identities of pumps containing PCBs are well known.

Future work aims to identify wells contaminated by PCBs from submersible pump motors and to advise affected homeowners about remedial measures.

The Ministry will ensure that the disposal of discarded pumps with PCBs is done properly.

REFERENCES

Humes, D. et al. (1986). Water Systems Council Report on Possible PCB Contamination from Submersible Pump Motors. Water Systems Council, Chicago, Illinois.

National Water Well Association (1986). Submersible Water Well Pump Motors and PCB Contamination - A Background Paper. National Water Well Association, Dublin, Ohio.

Versar Inc. (1979). PCB Contamination of Well Water: An Engineering Risk Assessment. Draft Task Report Contract 68-01-5048 Task 9. Office of Enforcement, U.S. Environmental Protection Agency, Washington, D.C. 20460.

New York State Department of Health (1986). News Release.

10661-05B.1

APPENDICES

APPENDIX A

Technical Details of Pumps Sampled in Ontario, and Results for PCBs in the Motor Oils.

RESULTS FOR SURVEY OF PCBS IN SUBMERSIBLE PUMP OILS. DATA FOR OILS SAMPLED AND ANALYZED BY ENVIRONMENT ONTARIO.

PUMP MOTOR NAME	PUMP SERIAL NUMBER	PUMP MODEL NUMBER	PUMP YEAR	# OF WIRES	VOLTAGE	HORSE-POWER	OTHER PUMP IDENTIFICATION MARKS	PCB CONC. (ppm)	PCB ISOMER (Aroclor)	COMMENTS ON OIL SAMPLES
CENTURY	S434232	?	?	3	230	1/2	4 amp.	5.0 <		LIGHT YELLOW
CENTURY	W146151	B66	1966	3	230	1/2		1.0 <W		YELLOW
F.E. MYERS	5B	7 73	1973	2	230(?)			4380	1242	DARK BROWN
F.E. MYERS	SA75230601567	166876	1976?	3	230			3.0 <		LIGHT BROWN
F.E. MYERS	?	?	1976?	2	230			1.0 <		BROWN
RED JACKET	33MI 3450	CODE P	?					5.0 <W		SAMPLE CLOUDY; WATER(?)
REDA	97J49		?	2	230	1/2	3 ins.	8.0	1242	CLEAR & COLORLESS
REDA	76348B83	7 63	1963	2	230	1/2	Type 62ST2	170	1254	BROWN
REDA	7705572B	7 70	1970	2	230	1/2	Type 62ST2	10000	1242	LIGHT YELLOW
REDA	0712954E	0 71	1971	2	230	1/2	Type 62ST2	160	1242/1254	LIGHT YELLOW
REDA	9871L		1971?	2				470	1242/1254	BROWN
REDA	2659-1	1 72	1972	2	230	1/2	Type 62ST2	330	1242/1254	LIGHT YELLOW
REDA	47316	6 75	1975	2	230		Model 12D9P071	3860	1242	LIGHT YELLOW
REDA	99118	7 76	1976	2	230		4 ins.	1.0 <		LIGHT BROWN
REDA	79274	276	1976	2	230	1/2	Type 62ST2	2100	1242	LIGHT BROWN
REDA	162814	9 77	1977	2	230	1	Model 17D9P101, 8 amp.	2360	1242	COLORLESS/CLOUDY
REDA	253741	7 79	1979	2	230	1/2	Model 9D9P351, 4 amp.	5.0 <		LIGHT ORANGE
STA-RITE	MP4H2E-8	M63	1963					5.7	1260	LIGHT YELLOW
STA-RITE	MP4C2A-4	J64	1964					10.0	(?)	LIGHT YELLOW

<W = Zero. Detection limit given. < = Zero. Actual value less than reported value.

RESULTS FOR SURVEY OF PCBS IN SUBMERSIBLE PUMP OILS. DATA FOR OILS SAMPLED AND ANALYZED BY ENVIRONMENT ONTARIO.

PUMP MOTOR NAME	PUMP SERIAL NUMBER	PUMP MODEL NUMBER	PUMP YEAR	# OF WIRES	VOLTAGE	HORSE-POWER	OTHER PUMP IDENTIFICATION MARKS	PCB CONC. (ppm)	PCB ISOMER (Aroclor)	COMMENTS ON OIL SAMPLES
STA-RITE	MP4B2A-4	G64	1964					3.8	1260	LIGHT YELLOW
STA-RITE	MP4C2A-4	F66	1966	3	230			95.0	1254	
STA-RITE	MP4D2A-6	B66	1966	3	230			6280	1254	DARK YELLOW/LIGHT BROWN
STA-RITE	MP4D2A-6	D67	1967					115	1254	LIGHT YELLOW
STA-RITE	MP4B2-3	H69	1969	3	230		BP 10B2C	61.0	1254	LIGHT YELLOW
STA-RITE	MP4B2-3	J70	1970					100	1254	LIGHT YELLOW
STA-RITE	MP4D2-7	F70	1970					254	1260	LIGHT YELLOW
STA-RITE	MP4B2-8	E71	1971					9.1	1260	LIGHT YELLOW
STA-RITE	MP4D2-9	M73	1973					5.0 <W		LIGHT YELLOW
STA-RITE	MP4C2-13	M73	1973	3	230	1/2		5.0 <W		LIGHT YELLOW
STA-RITE	MP4B2-6	B73	1973	3	230	1		1.0 <W		LIGHT YELLOW/SOME DEBRIS
STA-RITE	MP4C2-1	F74	1974	3	230	1/2		32.0	1254	LIGHT YELLOW
STA-RITE	MP4C2-13	C74	1974	3	230			20.0	1254	
STA-RITE	MP4C2-13	B74	1974	3	230	1/2		40.0	1254	DARK BROWN
STA-RITE	MP4B2-12	H74	1974	3	230	1/3		24.0	1254	LIGHT YELLOW
STA-RITE	MP4C2-7	F74	1974					5.0 <W		LIGHT YELLOW
STA-RITE	MP4C2-13	IB75	1975	3	230			13.0	1254	
STA-RITE	MP4B02	IJ75	1975					5.0 <W		WATER+OIL? CLEAR, COLOURLESS
STA-RITE	MP4B02-10	IL76	1976					5.0 <W		VERY SLIGHTY YELLOW
STA-RITE	M4D02S-01	IE77	1977	3	230	1/2		1.0 <W		LIGHT YELLOW
STA-RITE	M4D02S-01	M77	1977					5.0 <W		DARK YELLOW; RUST PARTICLES

<W = Zero. Detection limit given. < = Zero. Actual value less than reported value.

APPENDIX B

Results for Replicate Analyses

ENVIRONMENT ONTARIO INVESTIGATION OF PCBs IN SUBMERSIBLE PUMPS - Data for replicate analyses.

PUMP MOTOR NAME	PUMP SERIAL NUMBER	PUMP MODEL NUMBER	PUMP YEAR	# OF WIRES	VOLTAGE	PCB CONC. (ppm)	PCB ISOMER (Aroclor)	SAMPLE COLLECTED BY	SAMPLE ANALYZED BY
STA-RITE	MP4C2A-4	F66	1966	3	230	95.0	1254	Environment Ontario	Environment Ontario
STA-RITE	MP4C2A-4	F66	1966	3	230	74.5	1254	Environment Ontario	Environmental Testing and Certification, New Jersey
STA-RITE	MP4C2A-4	F66	1966	3	230	1.0 (		Environment Ontario	CBC-AquaSearch, Wisconsin
STA-RITE	MP4C2-13	C74	1974	3	230	20.0	1254	Environment Ontario	Environment Ontario
STA-RITE	MP4C2-13	C74	1974	3	230	32.0	1254	Environment Ontario	CBC-AquaSearch, Wisconsin
STA-RITE	MP4C2-13	C74	1974	3	230	22.4	1254	Environment Ontario	University of Wisconsin
STA-RITE	MP4C2-13	IB75	1975	3	230	13.0	1254	Environment Ontario	Environment Ontario
STA-RITE	MP4C2-13	IB75	1975	3	230	24.0	1254	Environment Ontario	CBC-AquaSearch, Wisconsin
STA-RITE	MP4C2-13	IB75	1975	3	230	16.2	1254	Environment Ontario	University of Wisconsin
STA-RITE	MP4B02	IJ75	1975			5.0 (W		Environment Ontario	Environment Ontario
STA-RITE	MP4B02	IJ75	1975			5.0 (W		Environment Ontario	Environment Ontario

(W = Zero. Detection limit given.

(= Zero. Actual value less than reported value.

APPENDIX C

Results for Sta-Rite Inc.'s Investigation of PCBs in Their Pump Motors

STA-RITE INC. INVESTIGATION OF PCBs IN DISCARDED STA-RITE SUBMERSIBLE PUMP MOTORS.

PUMP MOTOR NAME	PUMP SERIAL NUMBER	PUMP MODEL NUMBER	PUMP YEAR	# OF WIRES	VOLTAGE	HORSE-POWER	PCB CONC. (ppm)	SAMPLE COLLECTED BY	SAMPLE ANALYZED BY
STA-RITE	MP4D2-9	B73	1973				1.0 <	STARITE	CBC-AquaSearch, Wisconsin
STA-RITE	M4H04S-01	ID77	1977				1.0 <	STARITE	CBC-AquaSearch, Wisconsin
STA-RITE	M4E02S-01	ID77	1977				1.0 <	STARITE	CBC-AquaSearch, Wisconsin
STA-RITE	M4E02S-01	IG77	1977				1.0 <	STARITE	CBC-AquaSearch, Wisconsin
STA-RITE	M4C02S-07	H78	1978				1.0 <	STARITE	CBC-AquaSearch, Wisconsin
STA-RITE	M4D02S-01	IB78	1978				1.0 <	STARITE	CBC-AquaSearch, Wisconsin
STA-RITE	M4F02S-01	IF78S	1978				1.0 <	STARITE	CBC-AquaSearch, Wisconsin

APPENDIX D

Homeowners' Information Kit

INVESTIGATION OF PCBs IN DOMESTIC SUBMERSIBLE WATER WELL PUMPS

Homeowners' Information Kit

This kit contains a checklist and questionnaire to help you find out if you have a submersible pump that could be leaking PCB oils into your well.

Ontario Ministry of the Environment
Water Resources Branch
Drinking Water Section
June 1987

INVESTIGATION OF PCBs IN DOMESTIC SUBMERSIBLE WATER WELL PUMPS

Homeowner's Checklist for Signs of Possible Pump Oil Leakage

Results from an Environment Ontario investigation suggest that fewer than one percent of the 460,000 domestic water supply wells in the province have submersible pumps that could contain PCBs.

A submersible pump has a motor unit attached to a pump unit, and both are submerged in a well. This type of pump is used mainly in drilled wells.

Ontario has recorded only 2 cases of well waters with PCBs that came from submersible pumps. PCB oils had leaked from the motor units into the wells.

PCB levels in these 2 wells did not exceed Ontario's interim objective of 3 parts per billion PCBs in drinking water. This objective is based on a lifetime consumption of drinking water.

DESCRIPTION OF PUMPS THAT COULD CONTAIN PCBs AND THOSE THAT DO NOT

1. Pumps that could contain PCBs have 3 features. These are:

   (a) Submersible pumps rather than jet pumps

   Submersible pumps have their motors submerged in wells. This type of pump has been linked to PCBs in well waters.

   Jet pumps and other pumps with motors above ground (e.g. in basements) are not linked to PCBs in well waters.

   (b) Submersible pumps with oil-filled motors

   Some pumps with oil-filled motors could contain PCBs in the motor oils.

(c) Submersible pumps with oil-filled motors manufactured between 1964 and 1980

Oil-filled motors manufactured during this period could contain PCBs.

2. Submersible pumps in Ontario that do not contain PCBs have water-filled motors.

The makes of pumps with motors that could contain PCBs and those that do not contain PCBs, are listed in the table attached.

THREE THINGS YOU COULD DO

1. Check your water supply and pump

Use the following list to check your water supply and pump. You will be looking for signs of possible pump oil leakage and trying to identify your pump.

(a) Signs of possible pump oil leakage.

These signs are:

(i) drinking water has petroleum-like taste and odour; or

(ii) there is an oil-like film on water and fixtures.

These signs could result from leakage of pump oils into water supplies. However, other common water problems such as iron can cause similar signs.

(b) Identity of pump

Section 3 of the attached questionnaire shows the information you'll need on the pump and its motor.

2. Complete the questionnaire

After you have checked your water supply and identified your pump, refer to the attached table to see if the makes of your pump and its motor are listed there.

Fill out the questionnaire if:

- your drinking water has signs of possible pump oil leakage, and your submersible pump and motor are listed among those that could contain PCBs; or
- your pump/motor combination is not listed on this table.

3. Mail the completed questionnaire

Send it to the address given on the questionnaire.

WHAT THE MINISTRY WILL DO

Ministry staff will examine the information you have provided and contact you about follow-up.

WHERE TO FIND INFORMATION ON YOUR PUMP AND PUMP MOTOR

You should check your pump's control box first.

If the control box does not have the information, or if there is no control box, you have a number of options:

- Check the sales slip and warranty card for the pump.
- Contact the company that sold you the pump.
- Contact the previous homeowner.
- Ask a pump installer to help you identify the pump.

Names of domestic submersible water well pumps with motors manufactured between 1964 and 1980 that could contain PCBs and those that do not contain PCBs. Only the names of pumps commonly sold in Ontario during this period are mentioned.

MOTORS COULD CONTAIN PCBs (oil-filled, with or without internal capacitors)			MOTORS DO NOT CONTAIN PCBs (water-filled, no internal capacitor)
Name of Pump Manufacturer (Pump Name)	Name of Motor Manufacturer (Motor name)	Reasons Why Motor Could Contain PCBs	Manufacturers of the following pumps used Franklin Electric motors:
Aeromotor[2]	Century Electric	O	Aeromotor[2]
Berkeley[2]	Century Electric	O	Beatty
F.E. Myers (before 77/78)	F.E. Myers	O, C	Berkeley[2]
Peabody Barnes	Peabody Barnes	O, C	Goulds
Pumptron	Century Electric	O	Grundfos
Red Jacket[2]	Century Electric	O	GSW
Red Jacket[2]	Red Jacket	O, C	Home Hardware
REDA	REDA	O, C	Jacuzzi
Sears (75-78)[1],[2]	Sta-Rite	O	Layne & Bowler
Sta-Rite (U.S.)	Sta-Rite	O, C O	McDougall
Standard	REDA	O, C	Monarch
Tait	Century Electric	O	Pioneer
Webtrol[2]	Century Electric	O	Pumps & Softeners
			Sears[2]
			Sta-Rite (GSW)
			Southern
			Webtrol[2]
			F.E. Myers pumps with F.E. Myers motors (after 77/78)

O = oil-filled
C = Capacitor in motor.

[1]Manufactured during this time only.
[2]Used motor of more than 1 manufacturer.

Source: Environment Ontario survey of the pump industry.

ENVIRONMENT ONTARIO

INVESTIGATION OF PCBs IN DOMESTIC SUBMERSIBLE PUMPS

Questionnaire for
Information on Water Supply, Pump and Pump Motor

1. Name and Address: _____

_____

_____

_____

Postal Code: _____ Telephone #:( ) _____
(include area code)

2. Signs of Possible Pump Oil Leakage:

i) Drinking water has petroleum-like taste and odour.
Yes ____ No ____

ii) There is an oil-like film on water and fixtures.
Yes ____ No ____

3. Information on Pump and Pump Motor

- Make of Pump _____
- Model Name and/or Model # of Pump _____
- Year Pump Manufactured _____
- Serial Number of Pump _____
- Make of Pump Motor _____
- Model Name and/or Model # of Motor _____
- Serial Number of Motor _____
- Voltage _____
- Number of Electrical leads (2-wire or 3-wire) _____
(Do not include the green ground wire)

4. Return the completed questionnaire to:

Ontario Ministry of the Environment
Water Resources Branch
Drinking Water Section
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5